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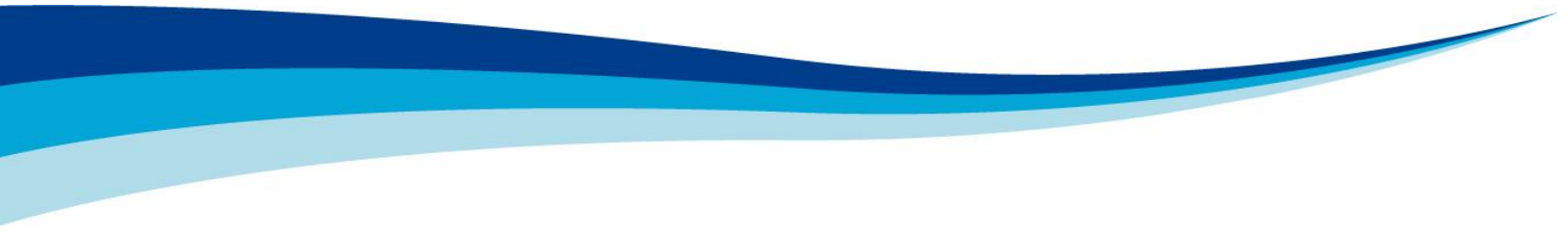
INTERNET PROTOCOL TELEVISION (IPTV) SERVICES



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BACHELOR´S THESIS | ABSTRACT
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The purpose of this thesis is to know what IPTV is and how the IPTV network architectures work. The role of IPTV is to deliver video, audio and data commonly called triple play services over an IP network. This thesis describes how video on demand (VOD) shows its relation to the IPTV and introduces unicast and multicast services, IPTV protocols such as RTP and RSTP, IPTV set-top box and some other common ways of this particular technology. It also demonstrates how the Sonera IPTV system delivers its services over the Sonera broadband internet connection. Advantages and disadvantages of this technology are also discussed in this thesis.

Video on demand is an IPTV technology that allows user to select and to watch IPTV programs on a TV or computer screen. In IPTV system, video on demand is an example of a unicast where the service can be delivered to a single recipient instead of everyone on the internet. Multicasting in IPTV system is a way of transmission in which the service can be delivered to a group of destinations over the network. The video can be viewed on a television or other display devices when it is delivered from a main server or an internet server.

KEYWORDS:
IPTV, VOD, Set-top box, Triple play

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FIGURES

1 Introduction

Over the past decade, the use of internet for sharing information, watching TV, business and entertainment has rapidly increased. In addition, the growth of satellite, digital cable, and HDTV services gives opportunity to reach a new discovery in a television broadcast system. Digitization of television is a technological innovation that allows for better quality and high definition images. Now, a new delivery method called Internet Protocol Television (IPTV) has been used in the telecommunications industry to offer more interactivity and best television services to the customers around the world.

IPTV is capable of receiving and displaying video streams that are encoded as IP packets from various broadcast channels. Internet Protocol Television (IPTV) is an IP-based technology that delivers Triple Play television services such as video, audio and data over Internet Protocol (IP).

IPTV allows video signals from another source to be captured, digitized, streamed and managed over an IP network. The video server then processes, compresses, edits and stores the captured video content that can be live or real-time or pre-recorded. After completing the process, the contents can be sent over an IP network to either single or multiple stations for private or simultaneous viewing. Today, with the growth of high speed internet connection, it is feasible to watch best quality television programs on display devices.

IPTV is supported by large telecom companies that provide IPTV services to their customers. Since IPTV appeared for the first time on the Internet, companies are trying to offer the best IPTV services to the consumers.

2 IPTV

2.1 What is IPTV?

IPTV (Internet Protocol TV) means television that is delivered over IP (Internet Protocol).
Digital television service delivered via a broadband IP link using data communications.
IPTV includes services such as video on demand (VOD), voice over IP (VoIP) and web access services, commonly called Triple Play services. The IP network for IPTV might be a public IP network such as the Internet or private data network such as a LAN-based network.

Since IPTV is not a standard, most subscribers are using propriety standards instead of global standards. Therefore, different operators implement IPTV networks in different ways which can create problems during updates and interoperability.
An IPTV network should provide the same services and content as cable networks, including broadcast television, channels selection, and anything which can be sent from a single source to many subscribers.

There are different types of IPTV, such as Telco IPTV and local or building IPTV. Telco IPTV is designed to deliver TV programs over Telecommunications providers such as the Internet, phone and cable using IP suits. The TV programs are delivered over an IP network at the same time as the Internet or phone services are delivered. Moreover,, the video contents is delivered through the same wire as the TELCO internet service executes the Quality of Service mechanisms on their network to make sure that the delivery of the transmission is reliable. Local IPTV is designed to

deliver television programs and video services across buildings and campuses over a Local Area Network (LAN). The video content is directly delivered into the building Local Area Network and the user can watch the channels on a TV or computer screen over the building LAN network.

IPTV has the following facilities:

- With IPTV, it is possible to pause or stop live transmission by using an IPTV set-top box. Therefore, the viewer can watch it later without missing any part of the TV program.

- IPTV records programs that can be played at any suitable time. The user can also record multiple programs at the same time with IPTV system.

- IPTV provides the best quality of sound and picture if the Internet connection is fast. Live and prerecorded broadcasting TV channels can be watched through IPTV. Therefore, a viewer does not have to miss any of his/her favorite show or a TV program running on the available channels.

- Since IPTV service is delivered over the Internet, the system is not affected by weather changes. Therefore, the system can provide normal transmission while the weather is rainy, cloudy or windy. [1]

Figure 1 shows how IPTV system collects contents such as audio, data and video or triple play services from different sources. The contents are

converted into a form that can be managed and distributed. The media contents can be stored, moved and sent out at specific times. Different programs are delivered to users who are connected to the Internet using the IPTV system. The IPTV set-top box transfers IPTV programming to the television or the computer screen for viewing, using an Internet connection.

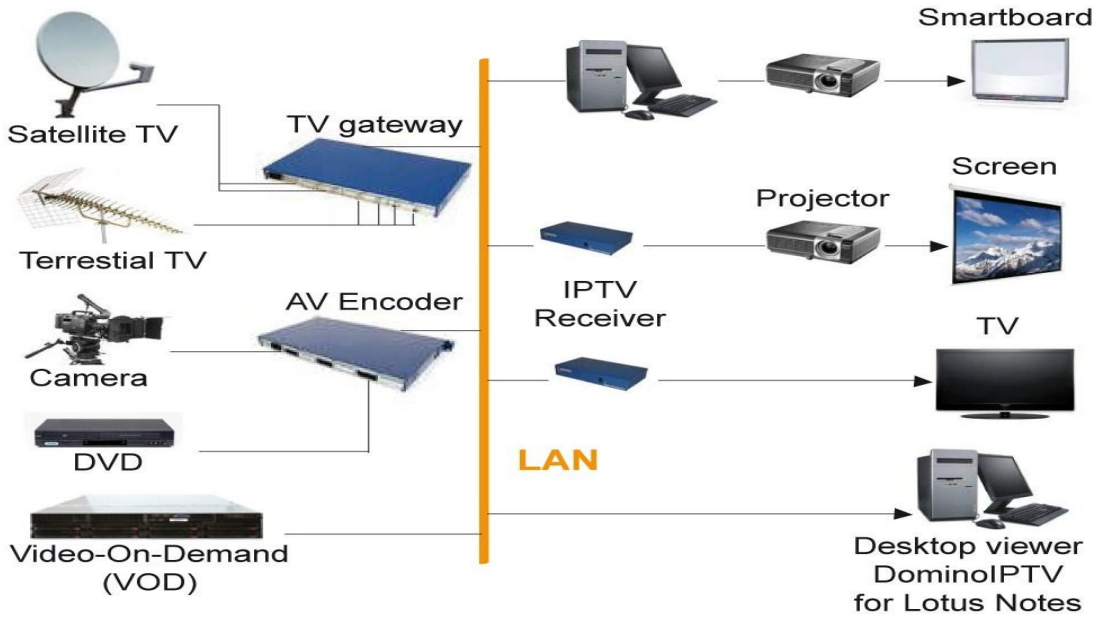

Figure 3. IPTV system

2.2 IP for IPTV

The Internet Protocol or IP is a common protocol which provides a data transmitting mechanism to manage packet flows between devices connected to the Internet. It is also a standard method for formatting data packets over a large network such as the Internet. A packet, which is defined as a collection of information, can be sent in a well-defined format over the IP network. In the IPTV system, a video signal will be divided into multiple IP packets and then the packets will be sent across the IP network.

Internet Protocol is widely used in different networks such as Local Area Network or LAN, wireless Wi-Fi network and telephony networks.

- In some developed countries, many people are using broadband networks in their homes. Therefore, video service providers do not need to build their own network and they can use the same networks to deliver video services.

- Internet Protocol can easily simplify video services such as program interaction, video on demand (VOD) and certain advertising.

- Nowadays, the IP networks can be found in every country in the world, thus the number of users with high speed internet connections is also growing rapidly.

- IP is an excellent network technology for many applications such as transaction of data (for example, email or banking), local area network, sharing files, web surfing and many more. [2]

2.3 Unicast, multicast and broadcast

Packet transmission is a process in which a packet of information is transmitted to the user over the IP network.

There are three different transmission processes, namely unicast, multicast and broadcast.

Unicast transmission: Unicast is a type of transmission in which a single sender and a single receiver communicate with each other over the network. Thus, the packet of information is sent from only one sender to only one receiver involving just two nodes.

In IPTV technology, video on demand is the main example of unicast transmission where the user can stop, pause, play, and replay the video contents. Therefore, with unicast transmission the user can control the data without disturbing other users on the Internet.

Some other examples of unicast include http, telnet, SSH, SMTP, pop3. With these applications, the information can be sent from only one sender to only one receiver.

In IPTV, the channel transmission may be sent directly to a specific viewer using unicast one to one transmission process. The same television program can be delivered to several users using unicast channel transmission. In this case, each user must be connected directly to the media.

Multicast transmission: In the multicast transmission the information can be sent from a single source to a selected group of destinations. The multicast process is commonly used to establish communication between a single sender and multiple receivers. Therefore, a single device sends data packets to a group of devices at the same time.

In term of IPTV, each broadcast TV channel should have a single IP multicast group in order to send data packets to a selected group of destinations. It means that hundreds of viewers will be able to simultaneously watch a single television broadcast. The broadcast packets will be sent to a group of clients and the clients can enable the broadcast stream route to their network device.

The use of multicast transmission is much more effective when the same packet of information is sent to many users at the same time. The multicast transmission is more complicated to implement than unicast transmission as more effort is required on the transmission to add and remove users from multicast groups. Figure 2 shows the difference between unicast and multicast transmissions. In unicast transmission, three streams from a single source go to three different destinations, but in multicast transmission system, only one stream goes to the group of destinations. [3]

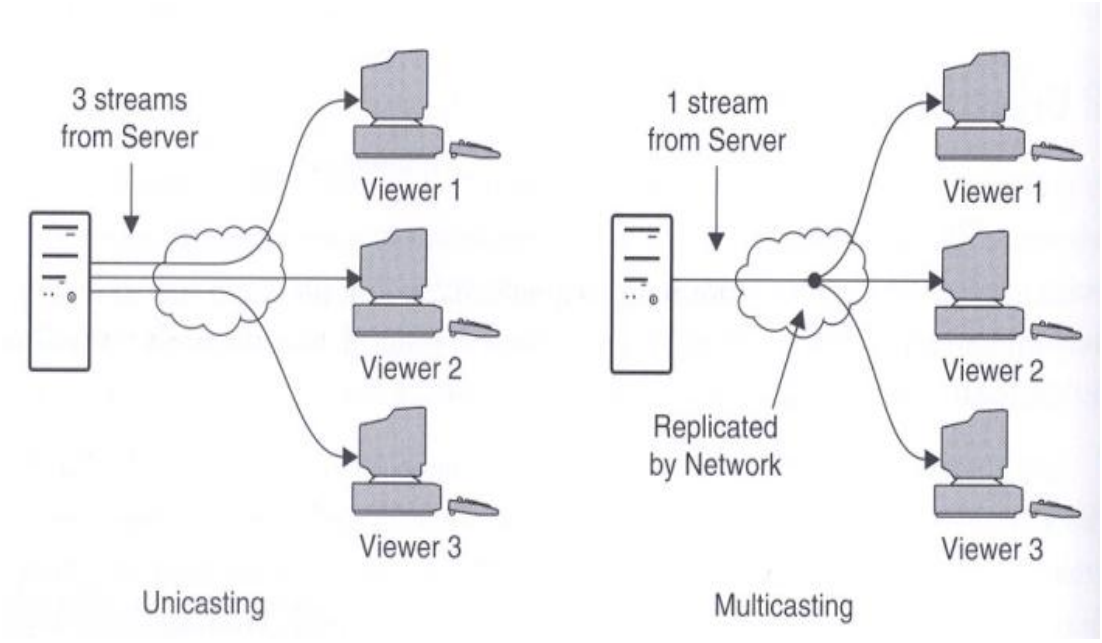

Figure 4. Unicast and multicast transmissions

Broadcast Transmission: With broadcast transmission, the packet of information is sent from only one sender to all receivers connected to the Internet. Therefore, all the receivers can get the information packet from the main single source.

2.4 Signal transmission

Signals are not transmitting over just one way. Signals can be transmitted over different ways such as cable and satellite to the TV, computer or other display devices. If the channels are free, the cable company is oriented to collect signals from all the different stations and goes to the viewer's home via cable or network. If the channels are payable, the cable companies scramble and keep the signals from being picked up by the people who do not pay for the service and then go to the subscribers homes via cable or the Internet. Signal amplifiers will be needed around the local area to keep the signals strong for the subscribers.

Today, the cable companies are using satellite dishes Instead of traditional antennas to collect signals from different stations included in their own service package. Some of the cable stations including ESPN, TBS, and HBO send their programs up to a satellite and then back down to the satellite dishes which are controlled by the local cable company. With this process, the signal problems caused by the landscape or by the curve of the earth can be eliminated and the initial signal arrives to the centre of the cable company.

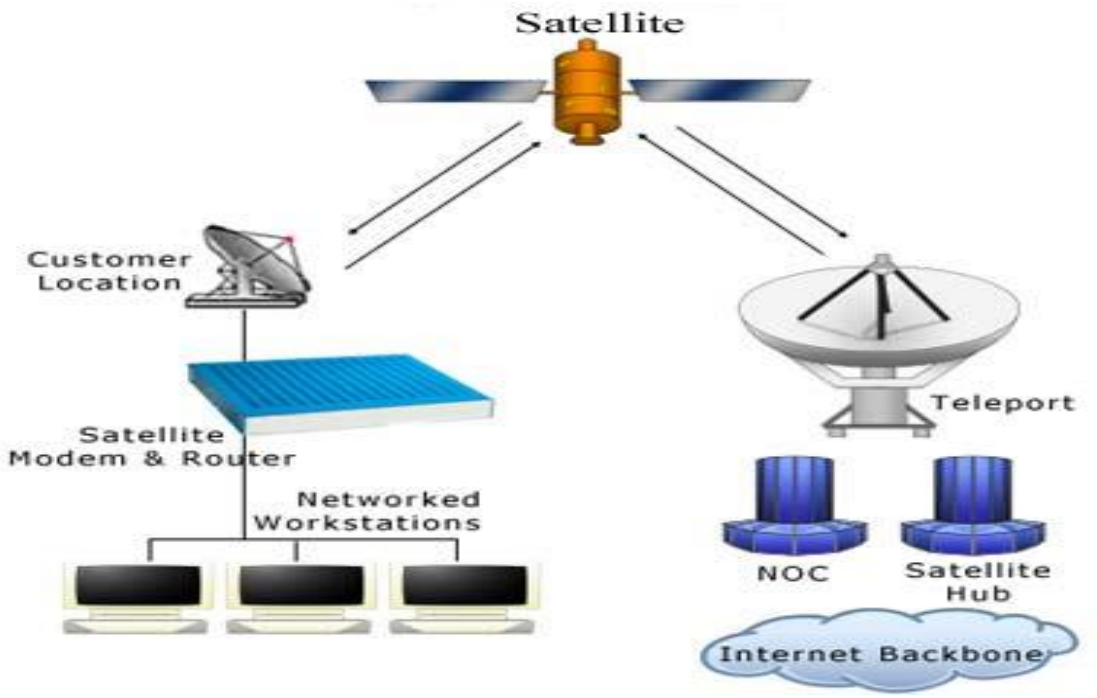

Figure 3. Transmitting of TV signals over the satellite

2.5 Protocols used for IPTV

RTP: Real-time Transport Protocol provides packet format for delivering audio and video contents over IP networks. The protocol is used for streaming channels controlled by Real Time Streaming Protocol (RSTP). RTP is commonly used in some streaming media services including telephony and video teleconference applications services.

Real-time Transport protocol and RTP Control Protocol (RTCP) work together. In this case, RTP delivers the media streams like audio and video over IP networks, while RTCP refers to monitor transmission statistics and quality of service (QoS) and helps to synchronize multiple streams.

RTSP: Real Time Streaming Protocol or controlling network protocol is used to control streaming media servers. Therefore, RSTP controls the delivery of data while RTP streams the channels. This protocol is used to establish and control media sessions from the server to the user. In order to start and stop data transmission, the media servers issue *play* and *pause* commands to easily control the transmission of media files from the server.

- RTSP is used to control unicast and multicast streams.
- Streaming of data in RTSP is one-directional. It means that data streams can be sent from the server to the user.

PIM: Protocol-Independent Multicast (PIM) is a set of multicast routing protocols that provide data distribution over IP networks such as the Internet, Wide Area Network (WAN) and Local Area Network (LAN). As it is obvious from its name, protocol independent, PIM is independent and it uses routing information provided by various routing protocols such as BGP or Border Gateway Protocol.
In IPTV, Protocol Independent Multicast (PIM) is commonly used to route IPTV multicast streams between networks.

IGMP: The Internet Group Management Protocol (IGMP) is used to manage membership in IP multicast groups. The protocol is widely used in online streaming video and gaming.

In IPTV, the Internet Group Management Protocol is a main part of the multicast specification over IP network. Therefore, the protocol is used by

IPTV in order to connect to a TV channel and to change from one TV channel to another. [4]

3 Compression system

3.1 Video compressions

Video signals are always compressing while delivering IPTV services over an IP network. Generally, compression means reducing the quantity of bits required for video image representations. Therefore, the compressed video reduces the required bandwidth for transmission of video over cable TV or satellite TV services.

Video compression is the most efficient method for delivering better quality video over an IP network. Many local TV broadcasters, cable TV and satellite TV systems are using the video compression method to allow much more video channels to be broadcast economically to the users.

Here are listed some of the main reasons for the use of compression in the IPTV system:

- Compressed streams can be delivered over a low rate internet connection while uncompressed streams cannot be delivered over a slow internet connection.

- Compressed video and audio files take less space on a hard disk or other storage devices than uncompressed original files. Therefore, it will allow user to save more contents in the storage devices. [9]

3.1.1 Moving Picture Expert Group (MPEG)

MPEG is a group of experts that developed standards for the video and audio compressions. The MPEG standard is used for coding video and audio content in a compressed digital format to provide best video and audio services. For example, digital TV, satellite TV, digital cable TV and high definition TV including Blue ray disks, are all using MPEG video compression technology to provide best video services. This technology is designed to compress data in order to form small bits that can be easily transmitted. The most common video compression systems that have been developed by the moving picture expert group are MPEG-1, MPEG-2, and MPEG-4.

MPEG-1 was the first video compression standard developed by the Moving Picture Expert Group in 1990. It is designed to be used in creating video CDs that is very popular in computer multimedia. MPEG-1 also provides a video compression method for DVDs where many DVD players can play video CDs as well.

Since MPEG-1 is today's most comfortable video and audio files in the world, it is used in many different products and new technologies. MPEG-1 is still usable in some low cost cameras and web video applications. Since MPEG-1 is a subset of MPEG-2, any MPEG-2 decoder can decode MPEG-1 signal. MPEG-1 cannot be used in NTSC, PAL, and 720P video systems because it does not support high definition video.

Today, the MPEG-1 compression standard should be considered as a legacy device and should not be considered for new implementations.

Figure 4 shows the MPEG-1 video and audio decoding process. This diagram shows how signal is decoded using MPEG-1 compression systems.

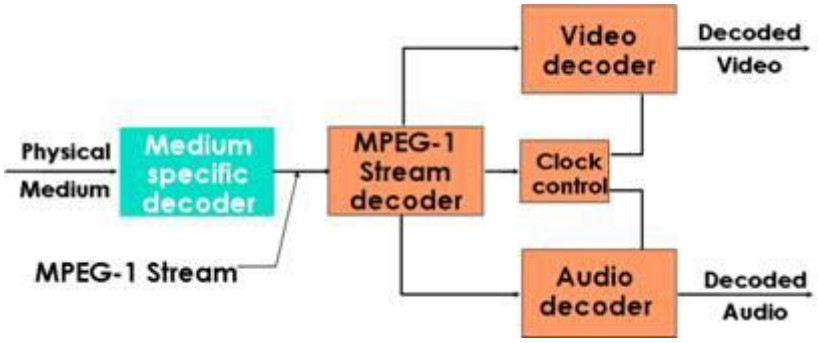

Figure 4. Decoding process using MPEG-1

MPEG-2 is one of the main standards for MPEG video that is established in 1996. It is also stable and perfect technology that is used in various applications including digital TV broadcasting and satellite and cable TVs productions. The MPEG-2 compression standard has more advantages than MPEG-1. For example, it has MPEG-2 support interlacing, thus it supports PAL and NTSC video stream at full resolution. MPEG-2 supports different types of resolution, performance profiles that specify techniques which can be used in video compression and it also supports multiplexing of video and audio streams. Thousands of hours of MPEG-2 video are recorded, processed, broadcast and played back by the television broadcasters every day. Millions of hours of MPEG-2 recording are sold publically every day in the form of SD or standard definition DVDs and thousands of PCs that have MPEG-2 playback capabilities are sold every week.

Generally, MPEG-2 is a constant and well-defined compression system that is widely used for professional quality videos around the world. Due to its stability and power, MPEG-2 will continue its popularity in the future for applications that required compatible installation of set top boxes (STBs) and digital TVs (DTVs).

Figure 5 shows the simple process of MPEG-2 system. It shows how signal is decoded using the MPEG-2 decoding process.

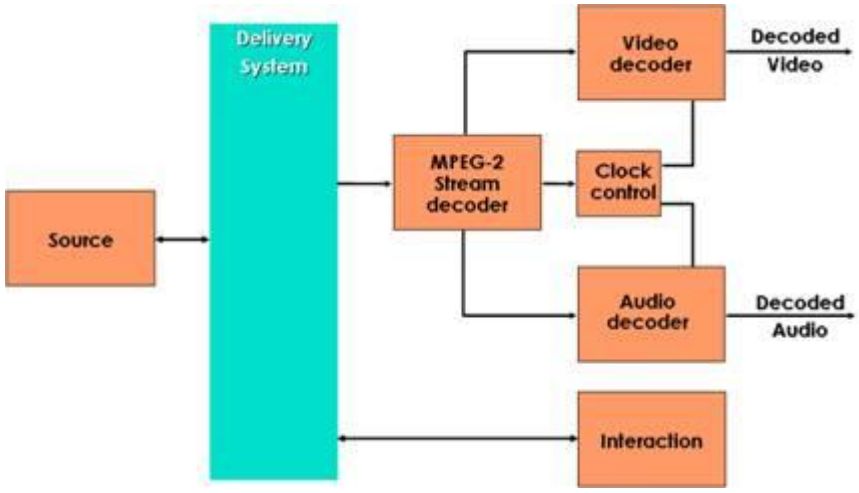

Figure 5. Decoding process using MPEG-2 system

MPEG-4 is a more recent video compression standard that was established in 2000. MPEG-4 contains new technologies for video compression. Advance video coding (AVC) or H.264 is the most new and powerful version of MPEG-4 video compression which enables high definition signals to be encoded at a lower encoded bit rate (10Mbps). It also provides a better technology for transporting high definition video signals. MPEG-4 compression technology can produce higher quality and clear image at lower bandwidth. In addition, it is very easy to implement MPEG-4 encoders and decoders. Figure 6 shows the simple decoding process of video and audio streams using MPEG-4 stream decoder.

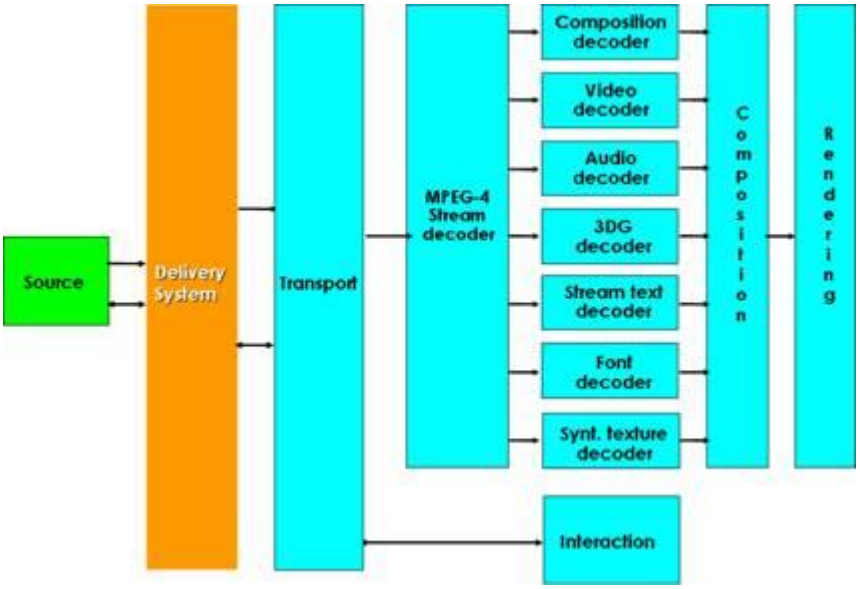

Figure 6. MPEG-4 decoding process

3.2 MPEG Audio compression

MPEG also has different audio compressions. There are 3 layers of MPEG audio called layer 1, 2 and 3. The most recent audio compressions are Advanced Audio Coding (AAC) along with High Efficiency Advance Audio Coding (HE-AAC) and HE-AAC+.

Layer one of the audio compression is the easiest compression system that uses 384 input samples while layer 2 uses exactly 1152 input samples for each running compression. Layer 1 that uses 384 samples is equivalent to 8 ms of audio material using 48 kHz sampling. Therefore, layer 1 can provide a stable bit rate at a compression ratio of 4:1. This means that 1.4 Mbps compressed audio signal can be achieved at 384 Kbps stream rate without having loss of quality.

Layer 2 that uses 1152 is equivalent to 24 ms of audio at 48 kHz sampling. It allows frequencies to be arranged more properly and provide better

compression of 8:1. It means that audio signal can be achieved at 192 Kbps of stream rate.

Layer 3 of MPEG audio has the same number of samples as layer 2, but it uses them more efficiently. Layer 3 uses variable length coding to put more efficient package of the compressed audio into the output stream. MPEG audio layer 3 is also related to the MP3 audio format that is commonly used to store and to compress audio files in order to transfer and playback on the audio players. The compressed MPEG layer 3 files are more popular in downloading music, swapping files, and some other portable player systems.

MPEG-AAC is an advance audio coding system that can be available only with MPEG-2 or MPEG-4 video streams. This system supports a large variety of tools that can be used by encoders to create best audio streams. MPEG-AAC supports up to 48 audio channels. [5]

4 Multimedia over IP

Multimedia plays a central role in IPTV as well as networking. Multimedia applications utilize different media types including graphics, audio, text, animations and video.

4.1 Video conferencing

Video conferencing also known as video teleconference is a telecommunication technology that transfers audio and video data between two different locations at the same time. Video conferencing would make an interesting product differentiator for an IPTV system. Video conferencing

includes the real time streaming of audio and video data over a broadband service and the system is also included within the IPTV set-top box. [6]

4.2 Video servers

Video servers carry out two main functions. The first one is called storage function that is responsible for keeping files of digital video contents on a hard disk. The second one is called delivery function that is responsible for delivering and transmitting video contents over an IP network for viewing. Sometimes, video servers contain different physical hard disk drives and processors for better reliability and performance. Video servers use RAID (Redundant Array of Inexpensive Disk) technology that store more data for each file. The use of this technology can increase the reliability of video servers.

Ingest servers: they are used to collect contents from different sources such as studio camera or satellite receiver, videotape, hard disk inside camera, and any other sources that produce video signal. After collecting these contents, the ingest server makes them available for use in a variety of applications. When the video has been ingested, then it can be transmitted to the various devices for further processing.

File servers: they are used in the video production process to store video clips temporarily from a color correction workstation before these clips passed to another workstation. File servers can also handle manipulated contents into their final forms. They have the ability to store contents and data that are repeatedly used in the video producing process such as theme songs or music process.

Production servers: these servers are used to play the final video contents that are ready to be played in highly reliable streams. Reliability is a key factor for production servers as any failures can cause the broadcaster to go off the air. These servers are using different technologies to obtain redundancy and to provide fail-safe operations.

Archives servers: these servers are used to store a huge amount of contents from different sources such as live broadcasts, news clips, purchased programming and so on. They are also used for a huge amount of storage at low cost and keeping video records of programming.

Video on demand servers: these servers are responsible for storing contents which are required by users for viewing. Video on demand servers create as many as possible simultaneous streams and sometimes they create multiple copies of the same contents.
High bandwidth IPTV network or internet connection is used for this purpose.

Live streaming servers: these servers are designed to take live streams and then generate multiple copies of the streams for transmission over an internet connection. Live streaming servers do not need storage for this process, but instead they need to have a huge amount of processing capacity to generate IP packets for the individual recipient of the stream.
Live streaming servers also need high bandwidth internet connection in order to transmit all of the streams created by them, to the IP network.

5 Characteristics of the IPTV system

5.1 Video on Demand (VOD)

Video on demand (VOD) is an IPTV technology that allows user to watch and to listen to TV programs on a TV or computer screen. With VOD, the user can select a favorite program or a movie to begin immediately. This technology streams the contents using a set-top box, computer or other devices in real time and downloads TV programs that can be watched and viewed later. A VOD system consists of a set-top box along with a standard TV receiver. Finally, the service can be delivered over the Internet to home TV using an IPTV set-top box and to portable or laptop computers, new mobile phone sets and advanced digital media devices. In order to provide best services for the consumers, IPTV providers need to ensure that their systems can support video on demand even now or in the near future. Video on demand performs the following tasks:

- Like any other video server, video on demand stores the video contents and has the ability to deliver multiple copies of a single content.

- It performs network interface function that is also similar to other video servers. But in this case, the video on demand server needs to support a huge number of simultaneous streams.

- It supports user interaction that gives the opportunity to the viewer to pause, replay and fast forward video contents.

- It also supports catalog and ordering which means that video on demand provides support for the systems which enable user to display the list of available contents.

True video on demand: True VOD is the special type of video on demand, where each user can receive an individual video stream which is under their control. Therefore, viewers have a free choice to start, stop, pause, replay, and forward the video contents. In this case, viewers typically pay a fee for each title viewed by them. They can pay fees either from their prepaid account or it might be a monthly bill.

Near Video on demand: This type of video on demand is similar to true VOD, but in this case the viewers do not have any control over the individual video stream. Stagger casting is one common type of near video on demand, in which multiple copies of a program are played at short time intervals (approximately 5 minutes).

Free video on demand: Free video on demand is a variation of VOD where viewers do not need to pay if they want to view video. In most VOD systems, this content is bounded to long form advertisements, guides and other low-cost content.

Subscription Video on demand: Subscription VOD has the same delivery technology and viewer control as VOD that gives users unlimited access to a selection of programs for their fixed monthly payments. In this VOD service, the users have control over a video stream where they can start, stop, pause, rewind and fast forward video contents.

Personal Video Recorders: A Personal Video Recorder (PVR) is an electronics device that compresses and records incoming video programming in a digital format to the hard disk located either in the set top

box (STB) or it might be a USB flash drive, secure digital (SD) memory card or other local or networked mass storage devices. With PVR, users will be able to set PVRs to record specific programs at specific times and control play back contents including pause, rewind and fast-forward capabilities. [7]

Figure 7. Simple IPTV video on demand

5.2 Triple Play

Triple Play means the delivery of voice, data and video over a single access subscription. An IPTV broadband network can handle all three (voice, data, and video) services. The common applications for this procedure are Telephony, Television and high-speed internet services.

The telephony option offers call services such as call forwarding, caller ID, call waiting, call screening, selective call blocking and call conferencing. The network operators are interested in carrying out all these services using the same access technology called Internet Protocol (IP), where IP is playing as a host for all the communications and signaling. The medium for the

transmission of these services might be fiber optic cable, conventional cable or satellite transmitter [8]. Figure 8 shows delivery of triple play services over the network.

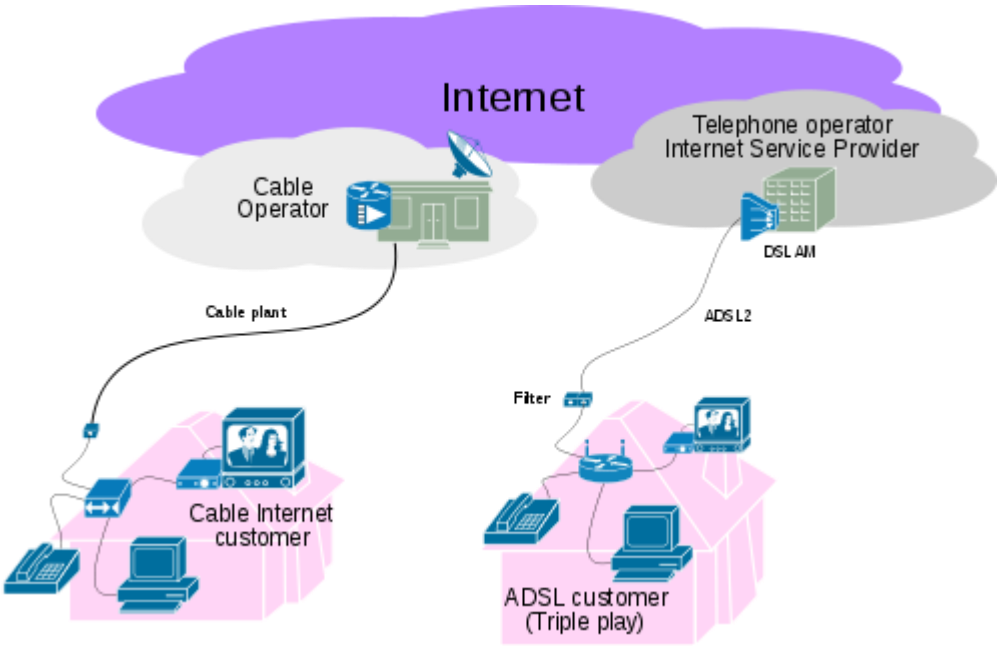

Figure 8. Delivery of Triple play services

5.3 IPTV Set-Top Box (STB)

A set-top box (STB) is an IPTV device that is commonly used to receive and decode digital television broadcast and to turn the signal into content which is then displayed on a television screen or other display devices. In order to view and watch programs on the television screen or other display devices, the STB must be connected to the usable device using an Internet connection.

Professional set-top box: Professional set-top-boxes referred to as Integrated Receiver Decoders or IRD are the professional method of the broadcasting video and audio contents to the television or other display devices. They are designed to work the best as they are technically superior.

Tornado M10 set-top box: The Tornado M10 advanced technology device is designed to deliver streaming audio, video, and data directly to the consumer TV screen. The Tornado set-top-box provides both advanced MPEG4 video and MP3 audio compression and has the ability to deliver contents with the best quality and limited bandwidth using IP networks such as the Internet. This device also offers advanced voice over IP (VoIP) capabilities to consumers, which gives them the best chance to make cheap internet phone calls. Some more services provided by Tornado M10 include video conferencing, video recording, news, email, voice mail, chat, local weather information, program scheduling and many more.

Figure 9. Tornado M10 IPTV Set-Top-Box

Hybrid IPTV set-top box: A hybrid IPTV set-top box as shown in Figure 10 is designed to deliver video contents and enables the accumulation of traditional linear TV broadcasts over both cable and IP networks such as the Internet. This kind of IPTV set-top-boxes allow viewers to view broadcast television and internet video on their display screen along with IPTV services such as VOD and internet browser by creating a new consumer TV experience.

Figure 10. Hybrid IPTV Set-Top Box

Wireless IPTV set-top box: Wireless IPTV set-box is designed to deliver IPTV contents over a wireless network connection.

Fyre TV has released the world's first wireless 802.11 B and G IPTV set-top box for delivering IPTV contents to the display devices using a wireless internet connection. This set-top box connects to displays using high definition multimedia interface (HDMI) and S-video interface that can take direct input from the Internet and deliver it to the display device. This technology can deliver high quality video and audio contents to the displays with high speed network connection. Therefore, with a fast internet connection, the users have ability to choose high, medium and low quality

streaming from the remote control which is belongs to the set-top box. Figure 11 shows a wireless IPTV set-top box. [9]

Figure 11. Wireless IPTV set-top box

5.4 Digital Subscriber Line (DSL)

Digital Subscriber Line or DSL is a high-speed Internet service that competes with cable Internet to provide high-speed internet access to the local customers. There are several options of Internet access such as dial up, cable, DSL, satellite, fiber optic, mesh wireless or point distribution wireless. DSL operates over a standard telephone connection like dial-up connection, but it is faster than dial-up, because DSL does not tie up the phone line. DSL Internet access is delivered across the telephone network using a DSL modem, which connects to the telephone wall jack and computer. Now,

many IPTV service providers deliver their IPTV services using the DSL network. The main components of the DSL network are central office (CO), remote terminals (RT), feeder plant and Digital Subscriber Line Access Multiplexer (DSLAM). A DSL modem must be installed to receive signals from the DSLAM and convert them into the appropriate form for the display devices such as a PC or a TV set [10]

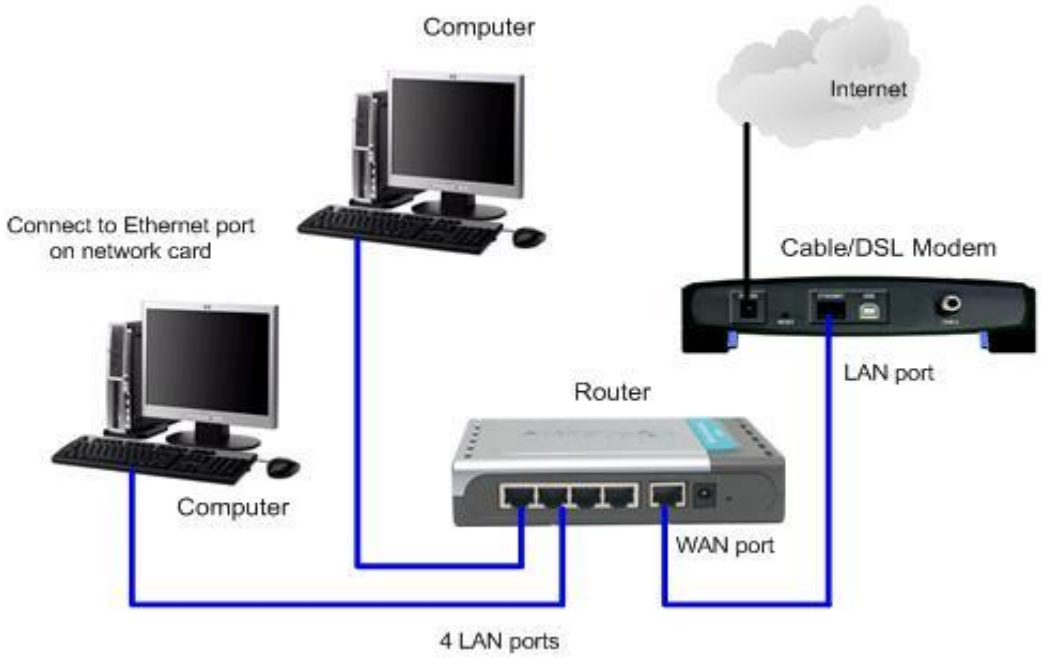

Figure 12. Configuration of the DSL network

5.5 Digital Subscriber Line Access Multiplexer (DSLAM)

A Digital Subscriber Line Access Multiplexer or DSLAM is a network device that connects multiple DSL connections using multiplexing technique to make faster connections to the internet. It is one of the key delivery elements in IP

video transport that receives signals from multiple customer DSL connections and puts them on a high-speed backbone line. At the Telephone Company or TELCO, the DSLAM device collects the data from its modem ports and combines their data and voice traffic into one complex composite "signal" using multiplexing method. Depending on the type of product and setup, a DSLAM connects the DSL lines over its Asynchronous Transfer Mode (ATM), Internet Protocol and frame relay. DSLAM enables a telephone company to offer the fastest DSL phone line services with the fastest backbone network technology called ATM to the business partner or home users. [11]

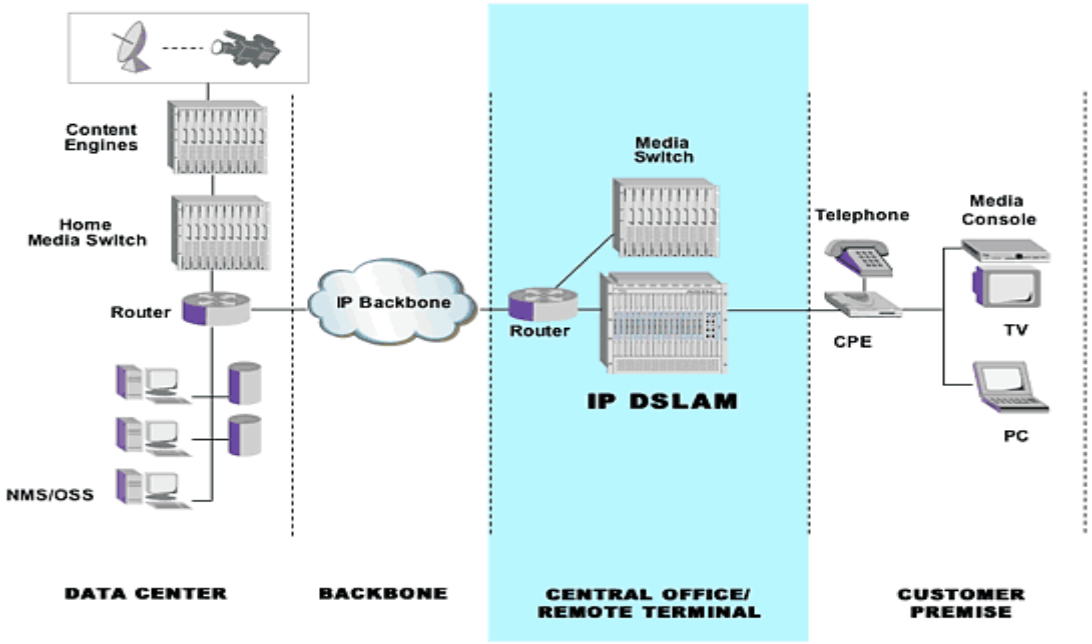

Figure 13. ADSLAM operation

5.6 Quality of Service (QoS)

Quality of Service or QoS is a combination of networking technology and networking technique. IPTV system requires a high level of QoS to provide best IPTV services to the customers. There are two main categories of the QoS, audio quality and video quality.

Audio quality: Audio quality is the quality of the audio output that enables the system to recreate the main characteristics of the original audio signal. It can be affected by several factors such as audio compression, transmission system and bandwidth limits. The recent audio compression technology helps audio files to remain in small size and deliver high quality audio signal. A poor transmission of audio signal is caused by packet loss or packet corruption. Packet loss happens when the network fails to deliver packets to the destination within a specific time. Packet loss can cause network congestion or equipment failures. The impression of packet loss on the audio system is to temporarily mute the audio signal. Packet losses are rare since the systems normally resend data packets that are failed to reach within a specific time. Packet corruption is the modification of data packets while transmitting over the network. It can happen due to a weak quality of the communication line. Therefore, if corrupted data is used, it will create different audio sound than expected.

Video Quality: Video quality is a quality of video output that enables the video transmission system to recreate the main characteristics of the original video signals. Similar to the audio quality, the same factors affect video quality such as video codec or video compression, transmission system and limit of bandwidth. Some of the distortions such as blurriness and edge noise will

affect analog video systems. Some factors such as tiling, block error, smearing, jerkiness, edge busyness and object retention will impair the digital video transmission system. Tiling means changing of the digital video image into square tiles that are located as unoriginal positions on the screen. Block error is a type of error in digital TV transmission system that does not represent error signals while compressing images. Jerkiness means skipping of the video image frames. Object retention is responsible for keeping of the frame portion when the image has changed. [12]

5.7 Mobile IPTV

This is a new easy and comfortable technology that uses mobile devices to receive and transmit multimedia traffic including video and audio contents, data and graphic services, and more IP-based functions using wired and wireless IP networks.

With this technology, the users will be able to enjoy various IPTV services over IP network everywhere.

Mobile IPTV is available on a limited level and very limited services. The new Mobile IPTV technology uses 3G of the mobile data network for running IPTV services on the mobile phone. Since IPTV is an advanced technology, it allows users to play previously recorded programs for fresh viewing.

The other benefits of this technology include switching the channels where users can switch various channels just like they switch them on their TV Set top box.

Further, with the pause option, the user can pause the TV program that can be watched later by the viewer.

Therefore, this technology gives a better quality of service by adjusting the video broadcast depending on the network connectivity.

The user does not need to buy an expensive mobile phone in order to use this technology, so a normal colored screen phone with fair display resolution and mobile data connectivity will be fine. The user needs to install Java applications on the mobile phone to properly use this technology service. Many new mobile phones support Java applications. Mobile IPTV services are provided by the Mobile operator, thus the application, service, channel packages and tariffs will be set by them. [13]

5.8 IPTV Testing

In order to test an IPTV operation, the measurements of the system, device or service that provide television services through a data network must be performed to validate its successful operation. The IPTV testing mechanism can be complicated as there are many interrelated processes where all these process can reduce the quality of the media services that are used to control the media flow.

Since the IPTV system is differ from a broadcast television system, IPTV is designed to use transmission systems that provide different levels of performance.

5.8.1 IPTV Testing over DSL

Figure 14 shows how to deliver Internet protocol TV (IPTV) using DSL. Nowadays, this is a better technology that gives many new business opportunities to the service providers. The voice, video and data services, commonly called triple-play services can be easily integrated by ADSL2 andVDSL2 over a single telephone line. With all these technological improvement it is now more practical to provide simultaneously multiple standard (SDTV) and high-definition television (HDTV) channels to the appropriate users. [14]

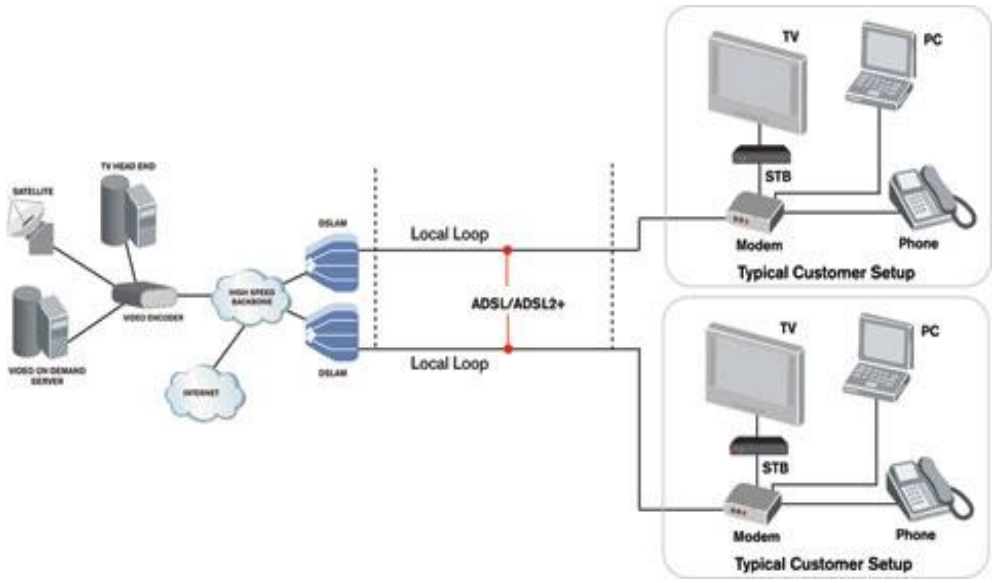

Figure 14.Typical IPTV over DSL network

5.9 IPTV network construction

Construction of IPTV networks can serve people over an IP network. IPTV can delivers hundreds of TV channels to the subscribers using an internet connection. The IPTV financial system is determined two main factors. The first factor is the calculation of the total number of homes or total number of residence which are connected to the IP network and the network connection is available for any customer who wants to become a subscriber. The second factor is the calculation of the total number of subscribers who have made subscription for the IPTV services to get IPTV videos to their display devices. There are some facilities constructed for the large IPTV delivery system to deliver video services across a large expanse of area.

5.9.1 Super Head End (SHE)

Super Head End (SHE) provides services to the large number of customers by processing the video contents that are commonly available to all subscribers. Therefore, a Super Head End (SHE) is used to collect the contents from different programs suppliers and convert them into the appropriate form and then deliver them over an IP network.

Generally, super head end (SHE) describes the following four functions:

1. Content aggregation: contents must be collected from different programming suppliers.

2. Conversion: the incoming contents should be converted into the appropriate form in order to deliver over an IPTV system.

3. Transport: the compressed video signals must be transported to the video service office (VSO) over IP network.

4. Formatting: the video contents must be formatted and then they can be transmitted to the viewers. The contents can be also delivered as a data files over an IP network.

5.9.2 Video Serving Office (VSO)

Video serving office is located in every required area to provide video delivery and video processing services for a single city or geographical area. Each video serving office obtains contents from a super head end and local programming sources. So, VSO is used for real time distribution of these contents to each central office in the area. Video serving office provides additional services such as customer billing and other related services. The following functions are included in the video serving office (VSO):

Localization: This is one of the most functions of the video serving office that processes specific contents to the local area. Similar to the super head end (SHE), the arriving local contents must be converted to the IPTV delivery format.

Compression: The video content processors convert different video signals that are compressed at one bit, into the different bit rate. These processors can also take video signals that are compressed using the MPEG compression system such as MPEG-2 and convert them into the different compression standards.

Creation of stream: Video serving office can create IPTV streams containing the packets that are sent to the central office. VSO can create one stream for each active viewer using simple remote equipment. Only one stream will need to be generated for each broadcast channel using sophisticated remote equipment. In this case, when multiple users are watching the same TV channel, the remote equipment is responsible for creating as many as needed copies of the same channel to send one to every active user.

Storage: The video serving office (VSO) and video on demand (VOD) functions are combined with each other. This means that they are used to create one way (unicast) streams that are delivered to the subscribers while viewing video on demand contents. In this case, each viewer will be able to pause, replay and fast forward the video streams.

Local ads: Local ads are very important sources for the IPTV operators. They can be inserted into both national and local programming. Advertisement servers are responsible for storing advertisements that are received from super head end (SHE) or other sources.

Interactivity: This is the main function for IPTV compared to satellite TV. With interactivity operation, commands are collected from individual set-top boxes to be processed at the video serving office. Selection, purchase and viewer control of the video contents are the main functions of the interactivity.

STB authorization: This function is very important to the financial purpose for the IPTV providers. The VSO system will confirm each authorized set-top box before it can get video contents for viewing. Two main functions can be taken during the encryption and scrambling process. Firstly, the IPTV operators must ensure that only paying customers are able to view contents. Secondly, they also must ensure that viewing contents are protected from retransmission and unauthorized duplication.

Fiber delivery: For this VSO function, the fiber optic network which contains numerous gigabit Ethernet lines can be used in order to provide connection between video serving office and central office or remote terminal locations.

5.9.3 Central Office (CO) and Remote Terminal (RT)

Some IPTV networks are using existing physical infrastructure of the telephone company, such as buildings. CO and RT are two locations where the central office includes call switching equipment and the remote terminal includes systems that connect subscriber lines including digital or fiber optic links to the neighboring central office. In both locations, the IPTV equipment can be installed to deliver IPTV services over digital subscriber lines (DSL). The installed equipment can perform several tasks including the following:

DSLAM function: There is one or maybe several digital subscriber line access multiplexer (DSLAM) units inside each central office (CO) or remote terminal (RT). The DSLAM is used to connect incoming video traffics from the video serving office to the DSL lines sending out to each subscriber. The IP address of each incoming packet must be examined by the DSLAM and then it can be delivered to the DLS line connected to the subscriber device with that IP address.

Multicasting technology: This technology is based on internet group management protocol (IGMP). Multicasting which is supported by some of the recent DSLAM is used to broadcast IPTV videos. In this case, the DSLAM has the ability to take one stream from the video serving office (VSO) and make multiple simultaneous streams of the single channel to multiple viewers at the same time. The video serving office must provide

individual video stream for individual users in the region if they do not wish to use multicasting technology.

Connectivity: DSLAM is also used to connect existing telephony system in the central office or remote terminal. In this function, the DSL splitter allows DSL equipment and the existing telephone equipment to share a single pair of copper wires that connects to each subscriber's home.

Combining services: Different IPTV services such as IPTV video and data services can share high speed bandwidth provided by a DSL line to the customer premises. The data traffic can be separated by the DSALAM within the central office and can be connected to an IP data router for future processing. The appropriately configured services such as voice over IP (VOIP) could also be separated by the DSLAM.

5.9.4 Customer premises

This is the most difficult environment for the IPTV operators. Some of the requirements such as power, physical location and a network wiring system are needed for the IPTV devices to be connected to the set-top boxes located in the customer homes. Different technology could be used for this purpose including coax, twisted pair and as well as wireless connection. The following technologies are employed here:

DSL modem: A stand-alone or integrated into a home gateway DSL modem must be configured in the house to get digital signals from the DSL connection and convert data into the usable forms for the other user devices.

DSL filter: This filter is responsible for preventing standard telephones from receiving signals that are processed by the DSL modem.

Home gateway: This gateway can be installed by some service providers to establish communications to multiple set-top boxes. It is also used to manage home network and convert between different types of cabling and the high speed DSL lines.

Set-top box (STB): The set-top box supports many functions in IPTV technology. It is used to decode digital video signals, provide graphics for the display screen, supports channel selection by the viewer and performs many other tasks. The set-top box must be suitable for each television set, otherwise the IPTV system might not work.

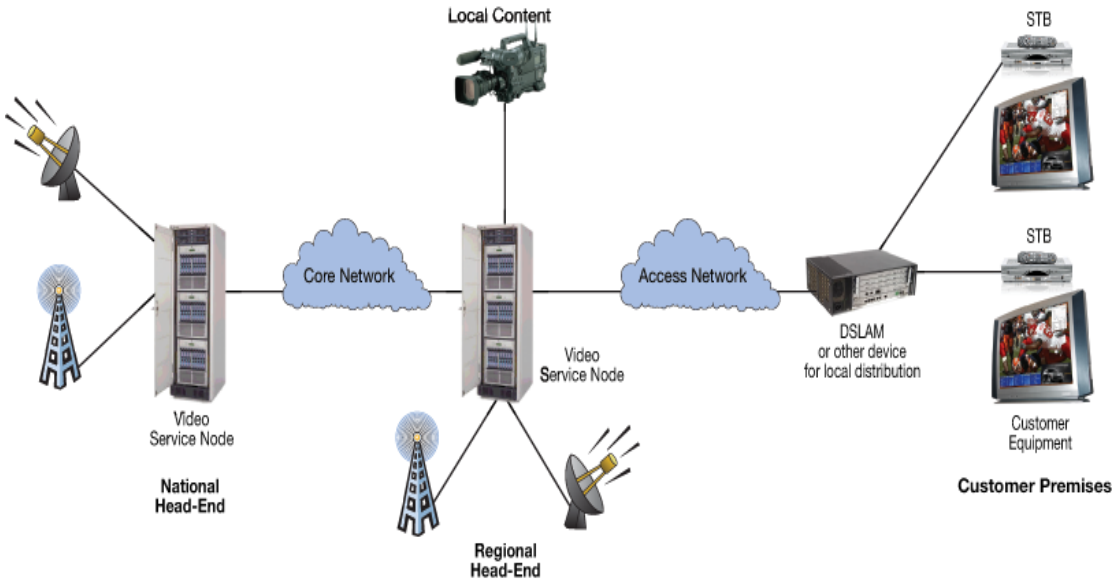

Figure 15. IPTV system architecture

5.9.5 Typical software capabilities

Software provides several key functions for the IPTV system. To watch IPTV videos on display devices, software is needed to perform this task. Some of the software functions available in the IPTV system are described as follows.

Electronic Program Guide (EPG): Generally, this is an on-screen menu that lets viewers to know which content is available on which channel or channels. The channels can be broadcast channels available for all users at the same time or be video on demand (VOD) content available for individual viewers. The IPTV network providers provide the program guide, but in some cases it can be purchased from an external supplier. There are two types of EPG, scrolling program guide (SPG) and interactive program guide (IPG). In the scrolling program guide, the content on every available channel is displayed in channel number order on a grid that slowly scrolls up the TV screen. However, in the interactive program guide, the channels and contents can be displayed on a TV screen where the viewers can use remote control to scroll up or down in the grid to view different available channels and to see detailed information about the current programs and they can also scroll to the right to see next programs.

Conditional Access System: The control access system (CA) controls the availability of programs to viewers. Therefore, CA controls which program is available for which user. For example, only the subscribed user to the premium movie channel is allowed to access and view that channel. It is fairly simple way to implement an IPTV system because the IPTV system needs to ensure that unauthorized viewers cannot receive the IPTV content.

Digital Rights Management System: The digital rights management system (DRM) is designed to control viewer action after the content is delivered. Therefore, DRM is used to protect property rights of the content owner after he/she received the content. This system provides some encryption forms and scrambling, thus the contents will not be viewable without the allocated key. In addition to the content scrambling, the system does not allow unauthorized copies or recordings of the contents to be made. [15]

5.10 IPTV Advantages and disadvantages

There are several advantages of the IPTV technology over current digital or over the air broadcast TV signals; here are a few of them.

Integration: Integration is one of the IPTV advantages as many companies offer several services in one integrated package. IPTV is one example of an integrated package with normal broadband Internet connection and Voice over Internet Protocol (VoIP). All these services can be delivered directly to the consumer. Therefore, the costs for the system can be reduced and the consumer only has to deal with one provider instead of more, making it more convenient.

Switched IP Technology: Cable TV broadcasters and Satellite TV broadcasters generally send all television signals at the same time and then the viewer chooses which signal to show on his/her television set. Therefore, lots of unnecessary bandwidth is used in this process.

IPTV commonly uses switched IP technology because the entire process is more efficient with this technology. In this case, all the TV data is held in a central location and only the chosen channel by the consumer at home is piped in. Since the bandwidth is no longer a big issue, this technology

provides the ability to add much data and much bandwidth in order to deliver services of a better quality.

Interactivity: Compared to cable, satellite or broadcast TV systems, it is very easy to perform interactivity with the IPTV system. Because the IPTV system delivers its services over the Internet directly to the consumer homes, it is very easy to move data from the TV company to the consumer home and from the consumer home back to the TV company. There are several ways of best interaction between the consumer and a TV company using television. With interactive TV, the viewers can buy or order products directly from their TV screen. Viewers can also request more information on a program that they wish to view on a TV screen.

Home Network: A television that is connected to the Internet, allows users to play stored media files such as digital photos, videos or music. Today, many computer monitors contain TV tuners, so viewers can also watch TV programs on their computer monitors. Therefore, if the computer has such a TV tuner, it means there is an additional TV set at home.

Video on Demand (VOD): IPTV system uses Video on Demand (VOD) which is an interactive and famous technology in the IPTV system. It allows users to conveniently request TV programs from the television. For example, users can easily turn on their TV set, scroll up or down through a menu and request the programming that they wish to view on a TV screen.

Better Compression: IPTV provides a better video and audio compression as well as creating best quality images and several programming options such as interactivity, integrity, networking and so on. Compared to the current

digital TV standard, the IPTV system uses an advanced compression standard to provide high quality TV images for the consumers.

Since the advantages of IPTV are much greater, there are some disadvantages that we should be aware of. Packet loss and system delay are some of these disadvantages. Like other types of data, the IPTV system uses IP technology to send and receive information. Considering this fact, if the Internet connection is not fast enough, the IPTV system may not work properly and will face to packet loss and system delay during the transmission process. [16]

6. Sonera IPTV

6.1 Sonera home TV or IPTV system

Sonera Koti TV or home TV is an IPTV system that requires Sonera's broadband connection to deliver video, audio and data services to the customers. Therefore, the IPTV service is delivered to the customers homes over the Sonera internet connection. The customers will be able to watch their favorite TV programs on their display devices using a Sonera IPTV set-top box.

Home TV uses Sonera's broadband network to transfer programs over the Internet. The capacity can be guaranteed and the programs can be presented with the same quality as the antenna broadcasts.

Sonera IPTV provides their services over a fast internet connection. The subscription can be ordered as an additional service that includes a Sonera IPTV box.

Sonera’s IPTV set-top box is designed specifically for home TV service. The set-top box must be connected to the TV set in order to delivers video signals to the viewer device.

The TV set must have a SCART or HDMI ports to be connected to the STB. Users do not need to have their own STB. The STB box delivers free antenna and cable channels that are currently in the residential properties, with a broadband ADSL or fiber optic access. If the user has already a set-top box, it can be connected to the home TV and the TV may have its own tuner.

The availability of home TV should always be checked individually. Sonera always check that the address is available on their broadband connection and then they check the availability of the home TV services. The availability of the service should always be checked from the customer’s street address.

6.2 Components of the Sonera home TV

Video on Demand: Sonera IPTV system has Video on Demand which means a service through which users can watch their favorites programs at any time suitable for them.

The Sonera IPTV video on demand system saves programs in the libraries that are free of charges. If some extra programs are needed then the users should pay for the ordered programs, but normally the access to the program library is free of charge.

With video on demand service, viewers can decide for themselves when and what programs they wish to watch on their display devices. Free programs have typically a day viewing period. The user who paid for a certain time does not have a limit of viewing to a particular program. All the videos can be viewed after the payment is done as long as the lease time is left. The user can forward or stop live program that can be viewed later. When applying for the program, the users should write the name of the program that they want to find just as they would write a text message.

The video service is available in all Sonera home TV connections. Video on demand does not require payment for the television services unless it is a program library which is tied to a specific channel package.

Payable channels: Home TV can be also connected to payable TV channels. Payable channels include programs for children, sports, documentary film and entertainment. Users can select the desired channel packages.

Payable TV services can be ordered from Sonera home TV services in residential properties, with a fiber optic broadband ADSL or Ethernet access. For the high definition TV channels, the 100mb speed of Internet will be needed, except for the Premier League HD channel which is also available on 24mb of internet speed.

Video storage: Sonera home TV is a free online storage feature that enables TV programs to be stored in a new way. Practically, this means that the users can watch their favorite TV programs at any time suitable for them.
With Sonera home TV system, the user can save programs from different free channels such as YLE TV1, YLE TV2, FST, Theme, MTV3, Channel Four, SUB, AVA, JIM, LIV, Suomi TV and the Voice TV. Payable TV channels can be saved using extra STB box to be ordered separately for an additional feature.

Video recording: Video recording is a very simple process. The user can press the (E or REC) button on a remote when the user chooses a TV program on a program guide before it begins. The user can also press the record button while watching a TV program and the recording starts at that moment. It is also possible to record programs from all the above mentioned channels at the same time.
TV programs are stored in a server located in the network, so the user does not have to worry about the breaking of hard disks. The user has a huge storage space which can accommodate up to 3,000 hours of TV programs. Therefore, the user can watch his/her recorded programs at any time for 90 days, after which they are automatically deleted. Figure 15 shows the program guide of the Sonera home TV that also enables user to record TV programs.

Figure 16. Sonera home TV program guide

Sonera Spotify: Sonera home TV also provides the Spotify service where the user can get a huge variety of music over the Internet. The user can access the service with a Spotify user name and password and can choose from over millions of songs. The playlists of the Spotify service can be created and edited on a computer or mobile phone. Spotify is available for all home TV subscribers.

6.3 Installation and activation process

Installation: The Ethernet port of the home TV set-top box must be connected to the Ethernet port of the broadband modem or the service router. In addition, the HDMI output of the digital set-top box is connected to the HDMI input of the television using the HDMI cable that is included in the Sonera Home TV installation package.

If the TV set does not have an HDMI input, the SCART socket of the digital set-top box can be connected to the SCART socket of the TV set using a SCART cable. After the configuration, the user can turn on the TV and the

power supply for the broadband modem and the power cord of the power supply to the service router should be plugged in. The power supply has to be connected to an electricity socket and the power cord should be connected to the digital set-top box. The device starts downloading the required software and the configuration may take several minutes.

When the user turns on the digital set-top box, five dots in a row will appear on the screen. The user has to wait until the dots have turned green one by one. The first time, all the dots are grey and a flashing yellow light indicates that the downloading is in progress. A green dot tells that the download has been finished. If all five dots are green, this means that the software of the set-top box is ready for use. The set-top box tunes the channels automatically and next, the user needs to activate Sonera Home TV.

Figure 17 shows the start and completed process of the sonera home TV set-top box.

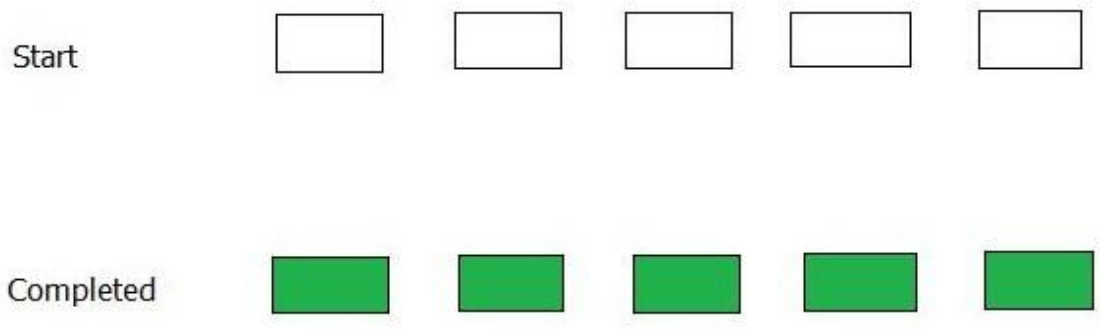

Figure 17. Starting and completion process of the set-top box

Activation: When the installation of the set-top box is finished, a menu will appear and tells the user to enter a user name and a password. The user name and password will be received in a text message sent by Sonera.

Home TV is activated using the remote control and the user should enter the correct user name and password. If the wrong number is entered, the user can return back to the first phase using the navigation button on the system remote control.

The service menu is the starting point of the Home TV services. Access to the contents will be available on the service menu by pressing the MENU button on the remote control. Figure 19 shows the service menu of the Sonera home TV. The service menu includes recordings, program guide, video rental shop, program library, settings and some other functions.

Figure 18. Service menu of the Sonera home TV

7 Conclusion

This thesis describes the IPTV system, a TV system that uses internet protocol (IP) and shows how IPTV technology in real life operates.

IPTV delivers Triple play services (voice, data and video services) using internet protocol (IP). IPTV is not the same as Internet TV. Internet TV programs can be watched by everyone through the Internet where the connection speed cannot be guaranteed and the programs' required bandwidth is regulated. In practice, the image size and resolution are thus worse than a regular antenna broadcast. In IPTV systems such as Sonera home TV, the TV programs are delivered to the specific group of users instead of everyone connected to the Internet. The connection speed will be guaranteed and the quality of video will be the same as the antenna broadcast. On the other hand, users need to have a Sonera IPTV set-top box in order to watch their favorite TV programs on a television screen or other display devices.

During the research on IPTV system, I have learned much about the architecture and characteristics of the IPTV system and I have realized the key role of the IP for this particular technology. I also learnt how triple play services are delivered using internet protocol. The increase of internet speed and the growth of IPTV technology can change the minds of people to choose watching TV programs over the internet. Since IPTV technology is still very popular, the number of both providers and users is increasing rapidly and the technology is now very important in the telecommunication industry. So, this technology will surely become more usable in the near future and IPTV providers will offer new services to the consumers.

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